National Exams December 2006

98-Elec-B7, Power Systems Engineering

Open Book examination

3 hours duration

NOTES

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit, with the answer paper, a clear statement of any assumptions made.
2. Any non-communicating calculator is permitted. This is an Open Book examination. Note to the candidates: you must indicate the type of calculator being used, i.e. write the name and model designation of the calculator on the first inside left hand sheet of the exam work book.
3. Any five questions constitute a complete paper. Only the first five questions as they appear in your answer book will be marked.
4. All questions are of equal value.

Problem 1.

a- What are the sources of unbalances in a high voltage transmission system. [5 Points]

Consider an experimental 2000 kV three phase bundle-conductor line. Assume that the total inductive reactance is 55 Ω, and that the shunt capacitive susceptance is 1.13 mS.

b- Calculate the sending-end voltage, sending-end current, power, and power factor when the line is delivering 16,000 MVA at 0.8 PF lagging at rated voltage using the long line representation. Neglect the series resistance of the line. [15 points]

Problem 2

a- Sketch the reactive capability curve of a synchronous machine, and explain the underlying principles for its various segments. [5 points]

b- A salient pole synchronous machine is connected to an infinite bus whose voltage is kept constant at 1.10 pu. The direct and quadrature axis reactances of the machine are 0.5 and 0.25 pu respectively. The table given below relates to three operating conditions of the machine. (Q_2 is the reactive power at machine terminals) Complete the table neglecting armature reaction. [15 points]

	P (pu)	**Q_2 (pu)**	**E (pu)**	δ
Condition A	?	?	1.15	25.0°
Condition B	2.0	?	?	20°
Condition C	?	-0.10	1.2	?

Problem 3

a- Explain the functions of insulating oils used in transformer tanks. [5 Points]

A 25-kVA, 2200/220 V, 60-Hz, single-phase transformer has the following equivalent-circuit parameters referred to the high-voltage side.

$R_{eq} = 6.0\ \Omega$ $X_{eq} = 24\ \Omega$

$G_c = 2\text{x}10^{-5}$ S $B_m = 5\text{x}10^{-5}$ S

Use the equivalent Cantilever model circuit of the transformer shown in Figure (1).

b- Determine the magnitude of primary current and voltage when the transformer supplies a secondary side load of 15 kVA at 220-V and a lagging power factor of 0.75. [5 Points]

c- Determine the value of the apparent power at the primary of the transformer, the power factor at the primary side and the efficiency of the transformer under the conditions of part (b) [5 Points]

d- Assume that the power input to the primary of the transformer is 24 kW at 2200- V and 0.8 power factor lagging. Determine the value of the kVA load on the secondary and the corresponding power factor. [5 Points]

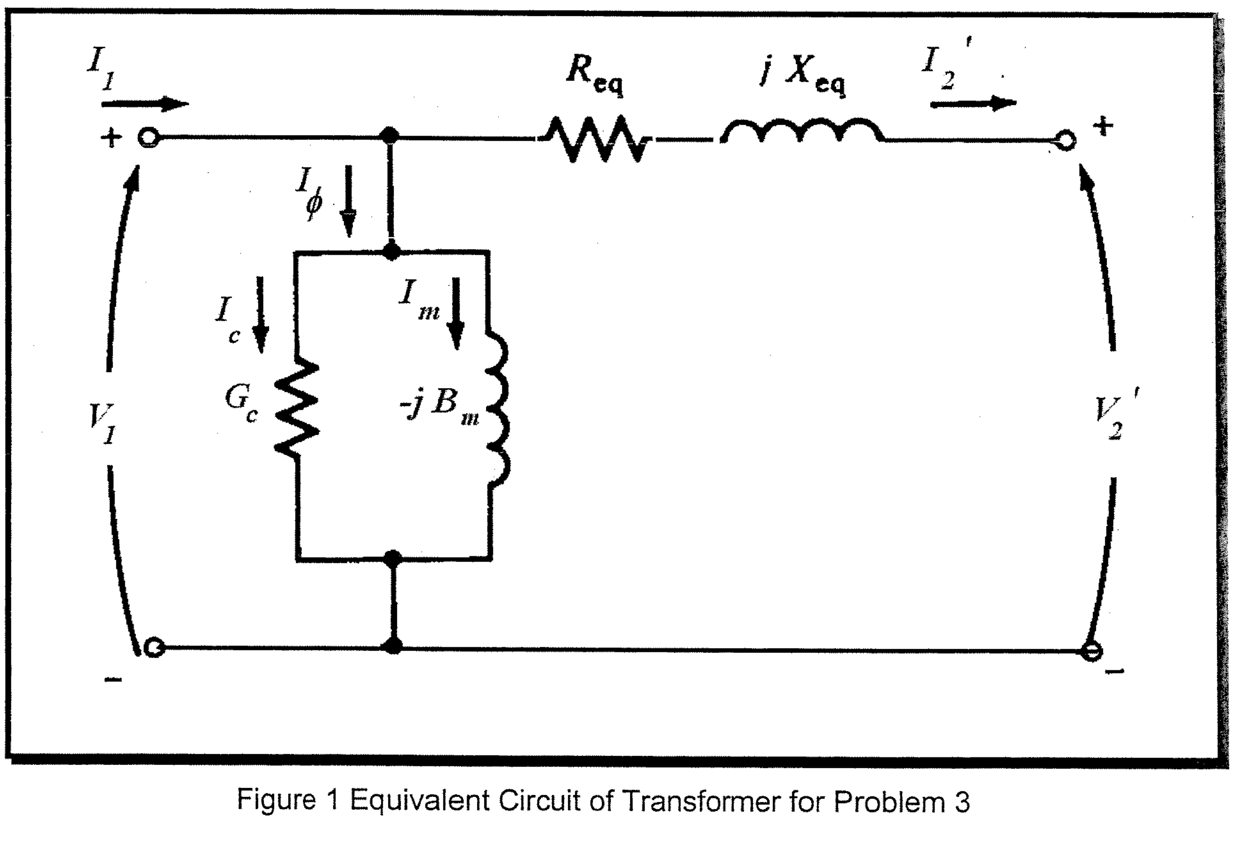

Figure 1 Equivalent Circuit of Transformer for Problem 3

Problem 4

a- What are the advantages and disadvantages of applying shunt capacitors in electric power systems. [5 points]

Consider the system shown in the single-line diagram of Figure 2, where the line admittance between bus 1 and 2 is the same as that between bus 1 and 3 as: $Y_L = 4 - j5$. It is required to:

b- Find the voltage V_2 and its phase angle exactly given that $S_{D2} = 0.9 + j0.7$. [5 points]

c- Find the voltage V_3 and its phase angle exactly given that $S_{D3} = 0.5 + j0.4$ [5 points]

d- Find the value of S_{G1} and the generator power factor under the conditions of parts b) and c). [5 points]

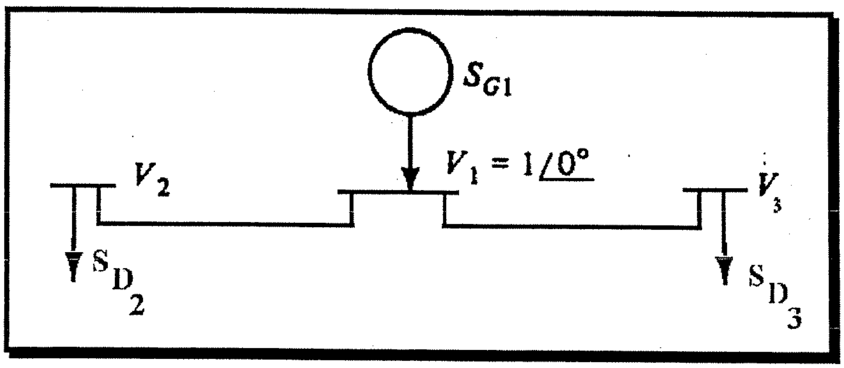

Figure 2 Single-line diagram for Problem 4

Problem 5

a- Discuss the main causes for short circuit faults in northern climates such as in certain parts of Canada. [5 points]

b- In the single-line diagram of Figure (3,) all line and generator reactances are shown in per unit to the same base. Assume that the excitation voltage for both generators is 1 p.u. Find the voltage at bus 3 due to a bolted- three-phase short circuit in the middle of line 1-2 at F as indicated in Figure (3). [15 points]

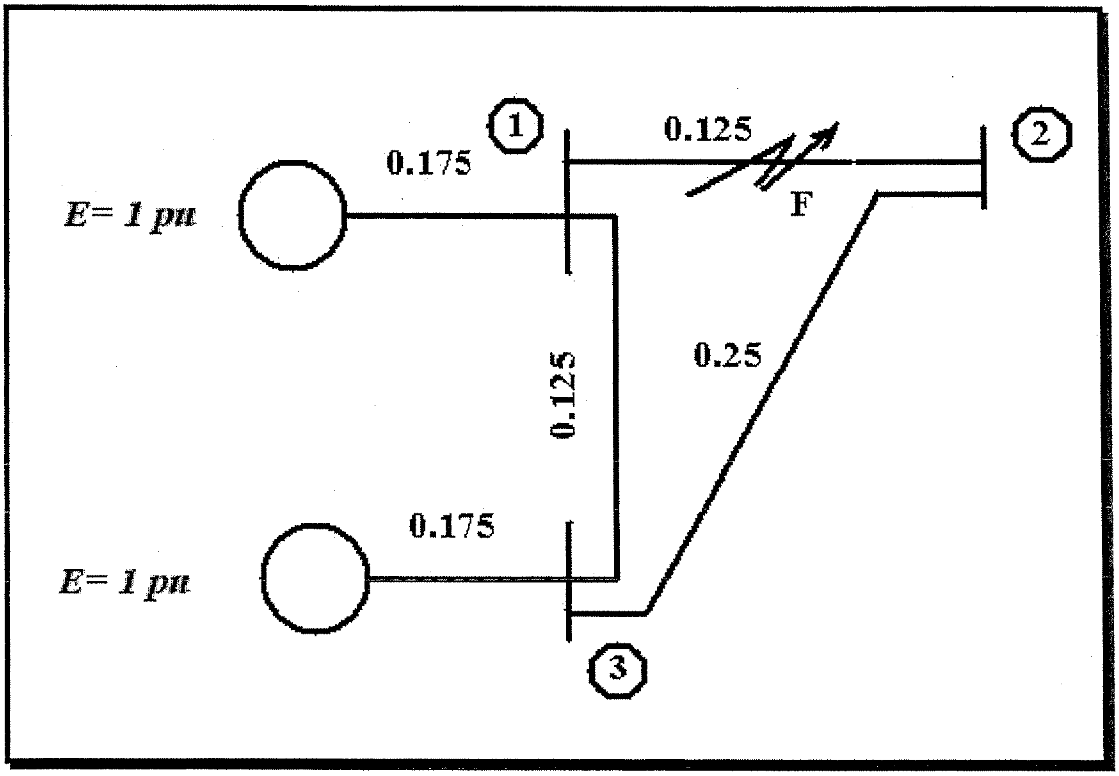

Figure 3 Single-line diagram for fault 1 in Problem 5

Problem 6

Consider the system shown in the single-line diagram of Figure 4. The required sequence reactances in per unit to the same base are as follows:

G_1	$X_1 = X_2 = 0.25$	$X_o = 0.04$
G2	$X_1 = X_2 = 0.2$	$X_o = 0.08$
Transformers	$X_{T1} = 0.04$	
	$X_{T2} = 0.05$	
Lines: Positive and Negative Sequence	$X_{12} = 0.10$	
	$X_{13} = X_{23} = 0.12$	
Lines: Zero Sequence	$X_{12} = 0.25$	
	$X_{13} = X_{23} = 0.30$	

Consider the case of a single line to ground fault on phase A at bus 3. Determine the currents through the phases of line 1-2 in per unit. [20 Points]

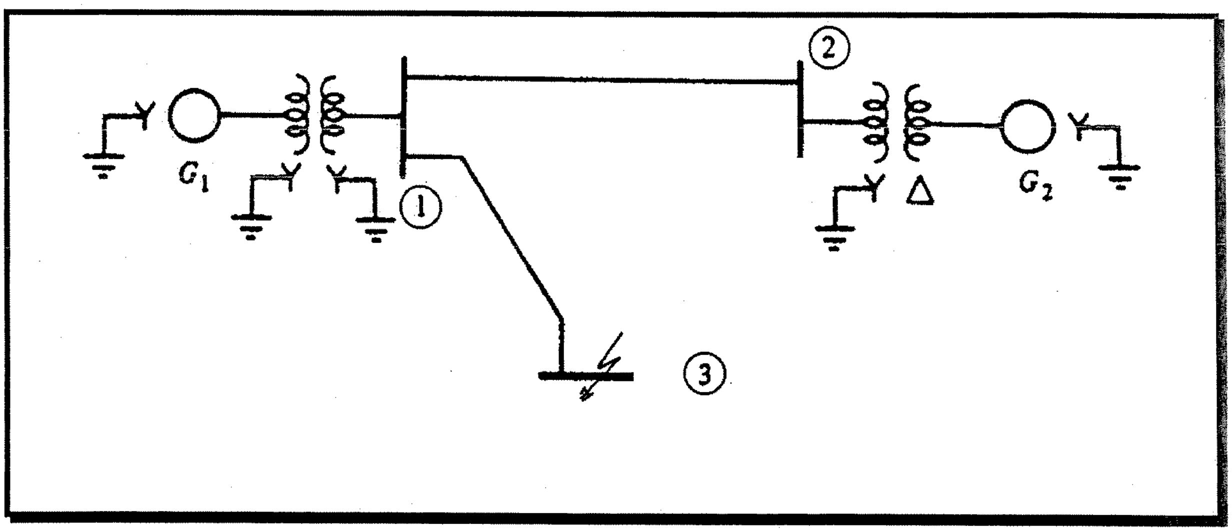

Figure 4 Single line diagram for Problem 6

Problem 7

Consider the circuit shown in Figure 5. Assume that E = 1.2 p.u., and V = 1.00 p.u. The reactive component of the load on the circuit is 1 p.u., when a three phase short circuit takes place in the middle of transmission line 3.

a Find the initial power angle δ and the active component of the load. [5 Points]

b Show analytically that the system will remain stable under a sustained fault. [5 Points]

c Determine the maximum angle of oscillation under a sustained fault. [10 Points]

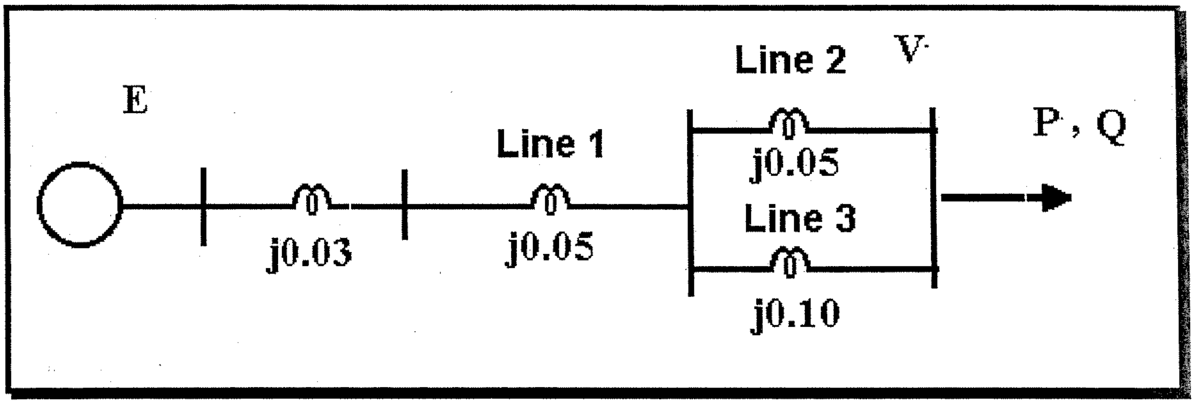

Figure 5 Circuit for Problem 7